Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 155 (2016) 285 – 288

Procedia Engineering

www.elsevier.com/locate/procedia

International Symposium on "Novel Structural Skins: Improving sustainability and efficiency through new structural textile materials and designs"

Surface modification of natural fibers: a review

Juliana Cruz*, Raul Fangueiro

University of Minho, Guimarães, Portugal, 2C2T

Abstract

In recent years there have been several attempts to replace synthetic fibers with natural fibers in fiber reinforced composites, due to increasing environmental awareness and depletion of oil resources. The fact that natural fibers are available cheaply and in abundance, being biodegradable and low density, has motivated many researchers throughout the world to explore their application potential in various industrial sectors. However, natural fibres also have some limitations such as high moisture absorption and subsequent swelling and degradation, poor chemical and fire resistance, high dispersion of mechanical properties, poor interfacial interactions with polymeric or cementitious matrices, etc. Therefore, there is a huge concern to modify the surface of natural fibers through various techniques, in order to overcome their inherent drawbacks and to successfully utilize these materials in various applications. This paper presents a review of existing research studies focused on the surface treatment of natural fibers and the use of nanocelulose, a natural nanofiber, for their application in composite materials

Peer-review under responsibility of the TensiNet Association and the Cost Action TU1303, Vrije Universiteit Brussel

Keywords: Natural fibres, Physical Techniques, Chemical Techniques, Biological Treatments;

1. Introduction

In In recent years several studies have been conducted to investigate the possibility of using natural fibers as replacement of synthetic fibers in fiber reinforced composites. Natural fibers have the advantages of low density, low cost and are biodegradable, but they also possess some drawbacks when used in composites, for example, poor compatibility with different matrices and high moisture absorption and swelling property that leads to formation of cracks in brittle matrices.

* Corresponding author. Tel.: +0-000-000-0000 ; fax: +0-000-000-0000 .
E-mail address: julianacruz@det.uminho.pt

Peer-review under responsibility of the TensiNet Association and the Cost Action TU1303, Vrije Universiteit Brussel
doi:10.1016/j.proeng.2016.08.030

Therefore, numerous techniques have been tried till date to modify the surface of natural fibers, mainly to reduce their water absorption and improve their adhesion with polymeric matrices. Cellulosic fibers in micro and nano scale are attractive to replace man-made fibers as reinforcement to make environmentally friendly green products.

2. Physical Techniques

Plasma treatment is a physical technique (Figure 1) which has been successfully utilized to modify the surface of various natural fibers. Mechanical properties of natural fibers were found to improve significantly after plasma treatment (F Oliveira 2012).

Additionally, plasma treatment can introduce various functional groups on the natural fiber surface and these functional groups can form strong covalent bonds with the matrix leading to strong fibre/matrix interface.

Also, surface etching due to plasma treatment may improve the surface roughness and results in better interface with the matrices through mechanical interlocking.

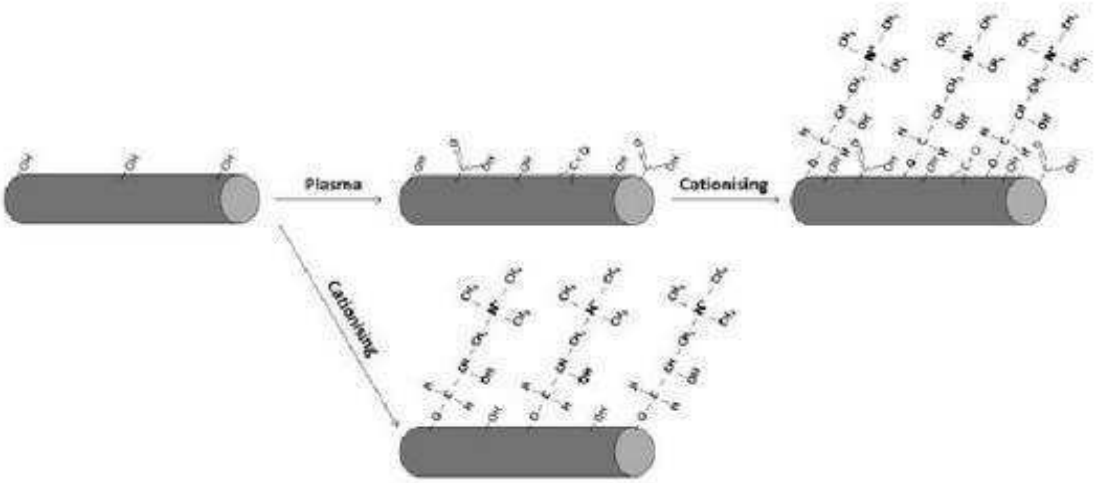

Fig. 1. Effects of plasma and cationising processes (Shahidi S 2013)

3. Chemical Techniques

Natural fibers have also been treated with various chemicals such as alkali, silane, water repelling agents, peroxides, permanganates, etc. It has been observed that some of these chemical treatments (for example, alkali treatment as can be seen in Figure 2) can significantly improve the mechanical properties of natural fibers by modifying their crystalline structure, as well as by removing weak components like hemicelluloses and lignin from the fiber structure (Xue L 2007).

Also, moisture absorption and subsequent swelling of natural fibers can be reduced through selective chemical treatments (e.g. water repelling agents). Moreover, chemical treatments (for example, with silane coupling agents) can also improve the fibre/matrix interfacial interactions through formation of strong chemical bonding and therefore, results in considerable improvement in the mechanical performance of composites (Yanjun Xie 2010).

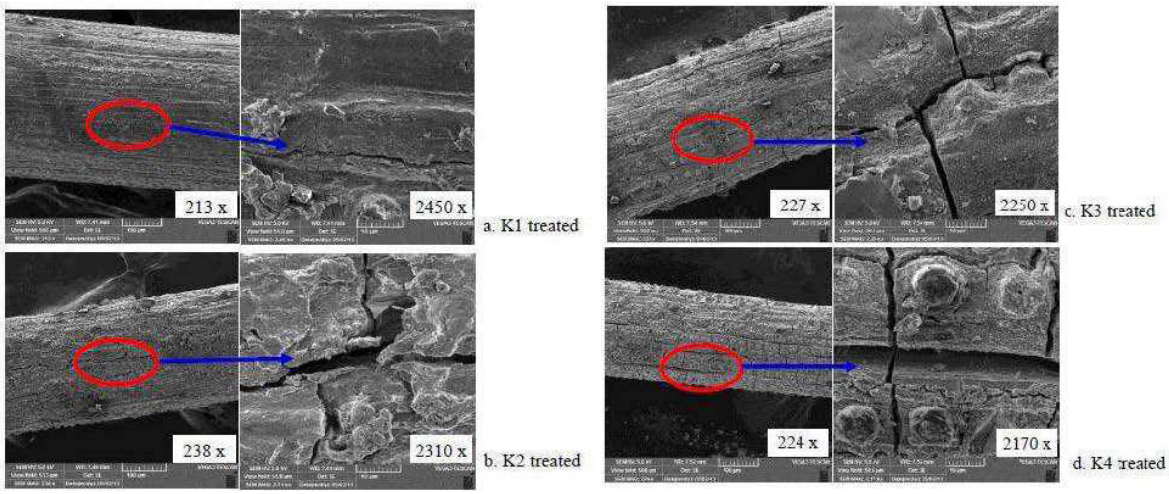

Fig. 2. Surface morphology of coconut fiber with alkali treatment (Muhammad A. 2015)

4. Biological Treatments

In addition to physical and chemical routes, natural fiber surface have also been modified using biological processes. In a recent study, cellulose nanofibrils were deposited on the surface of sisal and hemp fibers using them as substrates during the fermentation process of bacterial cellulose, see Figure 3 (Pommet M 2008). It was observed that the deposition of about 5-6% bacterial cellulose on the natural fibre surface resulted in significant improvement in interfacial adhesion with polymeric matrices such as polylactic acid and cellulose acetate butyrate.Therefore, this novel process of surface modification leads to the development of a new generation of natural fiber composites with improved fibre/matrix interface.

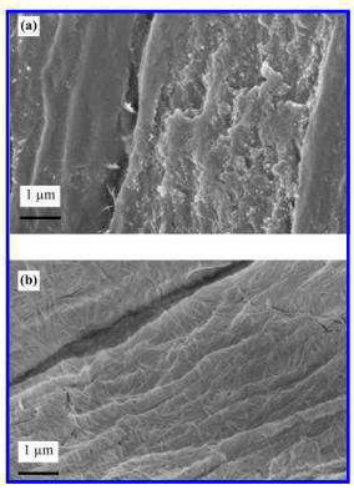

Fig. 3. a) natural hemp fiber; b) hemp fiber after bacterial cellulose modificationt (Pommet M 2018)

5. Conclusions

The surface treatment of natural fibers has been the subject of interest for numerous researches in order to fully utilize the advantages of natural fibres in composite materials and to successfully utilize them in various industrial applications.

However, research in this area is quite diverse and the existing literature talks about numerous techniques including various physical, chemical and biological routes.

Therefore, thorough review of the existing literature is extremely important to know the advantages and disadvantages of each treatment and to select the right one as per the requirements.

References

[1] Pommet M., Juntaro J., Heng J.Y. Y., Mantalaris A., Lee A. F., Wilson K., Kalinka G., Shaffer

[2] M. S. P. and Bismarck A, Surface Modification of Natural Fibers Using Bacteria: Depositing Bacterial Cellulose onto Natural Fibers To Create Hierarchical Fiber Reinforced Nanocomposites, In Biomacromolecules,2008, 9(6), pp.1643–1651.

[3] F Oliveira, L Erkens, R Fangueiro, A Souto, Surface Modification of Banana Fibers by DBD Plasma Treatment, Plasma Chemistry and Plasma Processing, 2012, 32, pp.259-273.

[4] Xue L., Lope G. T., Satyanarayan P., Chemical Treatments of Natural Fiber for Use in Natural Fiber-Reinforced Composites: A Review, Journal of Polymers and the Environment, Spinger, 2007,15, pp.25–33.

[5] Yanjun Xie, Callum A.S. Hill , Zefang Xiao , Holger Militz , Carsten Mai, Silane coupling agents used for natural fiber/polymer composites: A review, Composites: Part A, 2010, 4,1 pp.806–819.

[6] Shahidi S., Wiener J. and Ghoranneviss M., Surface Modification Methods for Improving the Dyeability of Textile Fabrics, January 16, 2013 under CC BY 3, ISBN 978-953-51-0892-4

[7] Muhammad A.,I Wardana N. G. Pratikto, Irawan Y.S, The morphology of coconut fiber surface under chemical treatment, Matéria (Rio J.) vol.20 no.1 Rio de Janeiro Jan./Mar. 2015 Epub Mar 2015, ISSN 1517-7076

[8] Pommet M., Juntaro J., Mantalaris A. and Lee A. F., Surface Modification of Natural Fibers Using Bacteria: Depositing Bacterial Cellulose onto Natural Fibers To Create Hierarchical Fiber Reinforced Nanocomposites, Biomacromolecules 9(6):1643-51, july 2008